Issued February 12, 1918.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Agronomist in Charge.
Mayaguez, P. R.

Bulletin No. 23.

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BY

R. H. VAN ZWALUWENBURG,
Entomologist.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., March 20, 1917.

SIR: I have the honor to tranmit herewith a manuscript by R. H. Van Zwaluwenburg, entomologist of the station, on the Changa or West Indian Mole Cricket. The changa or mole cricket, by far the most destructive insect known to the agriculturist in Porto Rico, causes enormous losses justifying the long series of investigations made of its life history and methods of control. This bulletin, which is the second publication by the station on the changa, carries the investigations much further than the first. It is not intended as final, however, as efforts will be continued to find more effective means of control, such as the discovery and introduction of natural checks.

I recommend that the manuscript be published as Bulletin No. 23 of this station.

Respectfully,

D. W. MAY,
Agronomist in Charge.

Dr. A. C. TRUE,
Director States Relations Service,
United States Department of Agriculture, Washington, D. C.

Recommended for publication.
A. C. TRUE, *Director.* ___ ___ ___ __

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

[1] On leave.

THE CHANGA OR WEST INDIAN MOLE CRICKET.

CONTENTS.

IMPORTANCE.

The most serious insect pest of general agriculture in Porto Rico is the West Indian mole cricket (*Scapteriscus vicinus*) or "changa," as it is popularly called on this island. The latter name is derived from the fancied resemblance of the insect's head to that of a monkey (chango). Although other insects may be more destructive to special crops, as, for example, white grubs to sugar cane and flea beetles (*Epitrix* spp.) to tobacco, the changa causes such serious damage to agriculture in general that it takes first rank as an insect depredator. Barrett in 1902 (2, p. 5)[1] stated that "the changa's damages to tobacco, cane, and small crops in the island amount to probably more than $100,000 annually." Improved control measures have greatly reduced the loss to cane and especially to tobacco since that time. It is to the general gardener that the changa now does most harm. It should be recognized, however, that much damage done to miscellaneous crops by other crickets and by cutworms is mistakenly attributed to the changa, which, on account of its conspicuous size, is well known to even the most casual observer.

The mole cricket is found in neighboring tropical countries having about the same soil and climatic conditions as Porto Rico, but it is only in this island that the insect has become of serious importance in agriculture. Possibly some very effective parasite, as yet undiscovered, holds it in check in its other habitats, or, perhaps, a combination of circumstances, such as suitable soil conditions, favorable cultivation methods, and absence of certain predacious enemies, is the cause of the insect's greater destructiveness in Porto Rico.

[1] Figures in parentheses refer to the bibliography found on pp. 25–28; other figures refer to footnotes.

CLASSIFICATION AND SYNONYMY.

The changa is a member of the insect order Orthoptera, which contains the roaches, walking sticks, mantids, grasshoppers, locusts, and crickets, and is said to number at least 10,000 known species.[1] According to recent systems of classification[2] the mole crickets, with their fossorial forefeet, form the family Gryllotalpidæ, but they were formerly considered as a subfamily of the cricket family Gryllidæ. The changa is the only mole cricket known to occur in Porto Rico.

The species was first described by Scudder in 1869 (41). Gundlach and Stahl both mention the insect as *Gryllotalpa hexadactyla*, which is a quite different species and is not known to occur in Porto Rico. Saussure in 1870 considered this species to be merely a variety of *S. didactylus*. Rehn and Hebard have recently published the opinion that "the species found abundantly in the southeastern United States, the West Indies, and portions of South America, and which has been frequently recorded as *S. didactylus*, represents instead *vicinus* of Scudder. This species is very closely related to *didactylus* of Latreille (described from Surinam and found elsewhere in South America and northward to Costa Rica), but is somewhat heavier." As given by Scudder in his table for the separation of species of Scapteriscus (41, p. 7), *S. vicinus* differs from *S. didactylus* in that the tibial dactyls almost or quite touch at the base, whereas in *S. didactylus* they are distant from each other at the base by at least one-half the width of the dactyls. Rehn and Hebard consider *S. agassizii* of Scudder synonymous with *S. vicinus*.[3]

HISTORY AND DISTRIBUTION.

In economic literature this injurious mole cricket has always been treated under the specific name *didactylus*, a name, as above stated, now applied to a closely related species. The first mention of the insect as a pest appeared in 1836 in letters from A. M'Barnet, of St. Vincent (32), who described the cricket as injurious to pastures and to cane plantings. Although the pest is named only as the "mole

[1] Sharp, D. Insects, I. Cambridge Natural History, vol. 5, p. 201. London, 1895.

[2] Brues, C. T., and Melander, A. L. Key to the Families of North American Insects, p. 14. Boston and Pullman, Wash., 1915.

[3] Since the above was written Mr. James A. G. Rehn, in a letter dated Apr. 7, 1917, has defined the range of *Scapteriscus vicinus* and *S. didactylus* as follows: "The limits of its [*S. vicinus*] range appear to be, as far south as Las Palmas, Chaco, Argentina, and Santa Cruz de la Sierra and Puerto Suarez, Bolivia; west to the Rio Pacaya, Peru; east to Piauhy, Brazil; and north to Colombia and Venezuela and through the West Indies, occurring also in eastern Georgia. The range of true *didactylus* appears to be limited to a relatively circumscribed area in northeastern South America from eastern Venezuela through the Guianas to lower Amazonian Brazil. This information on *didactylus* has not been published as yet, but is clearly evident from material in our collections."

cricket," the insect in question is without doubt this species. Harris in 1862 (27) mentioned this species under the name *Gryllotalpa didactyla*, as destructive to sugar cane in the West Indies.

Gundlach in 1886 (25) was the first writer to record the changa from Porto Rico. He states that it is not common in Cuba, but does considerable damage in Porto Rico, at least in the vicinity of Mayaguez. In 1887 the same writer (26) notes the flight of adults to lights and again mentions the insect as being especially abundant in Mayaguez. Brunner von Wattenwyl and Redtenbacher in 1892 (7) mention collecting this species in St. Vincent during January, and give the following localities as habitats of the insect: Haiti, Panama, Peru, Uruguay, and Argentina. In 1895 Fernando López Tuero, of the Spanish Agronomic Station at Rio Piedras, Porto Rico, gave a popular account of the changa as a pest of sugar cane (31) with notes on its life history.

The first extensive account of the changa was published in 1902 by Barrett (2), entomologist and botanist of the Porto Rico Agricultural Experiment Station. Like most of the previous writers, he used the specific name *didactylus*. He outlined the habits of the insect and gave recommendations for its control. According to him the changa has been very troublesome in Porto Rico only since the hurricane of 1876, which is supposed to have destroyed most of the insect's bird enemies. After 1885 the insect seemed to decrease slightly in numbers until the hurricane of August, 1899. It is the common belief in Porto Rico that the insect was introduced into the island about 1850 in a load of guano brought to Mayaguez. The first estate in Porto Rico to abandon cane culture because of the changa's ravages is said to have been the one in Mayaguez upon which the experiment station is now located. At present the insect seems to be more numerous and troublesome in the eastern part of the island.

The changa has become well established in the southeastern United States. In 1912 Worsham and Reed (54) published an account of the mole cricket's habits and development and the damage done by it in the coastal counties of Georgia, where it has been known since 1899 (11). Prof. J. R. Watson, of Gainesville, Fla., writes[1] that flourishing colonies of this insect have become established in the vicinity of Tampa and Miami, and he suspects that the insect is generally distributed throughout Florida, although there are only three authentic records of it from the State, all of them from the southern part. According to Dr. W. E. Hinds,[2] the species is probably present generally throughout Alabama, and complaints of its

[1] Correspondence Sept. 29 and Nov. 16, 1916.
[2] Correspondence Oct. 25, 1916.

damage are not uncommon there. It is not known to occur in Louisiana.

The changa has been found in St. Croix,[1] but is so rare there that no noticeable damage has resulted. It is not known to be present in Santo Domingo, although Haiti is listed in its range. "A species of mole cricket, said to be the same as the Porto Rican changa, appeared in such numbers in Venezuela several years ago that the cultivation of cane had to be abandoned." (20, p. 348.)

The present known distribution of the changa is as follows: Georgia, Alabama, Florida, Cuba, Haiti, Costa Rica, Panama, Porto Rico, Culebra Island (P. R.), St. Croix, St. Vincent, St. Lucia, Trinidad, Barbados,[2] French and Dutch Guiana, Brazil, Uruguay, Argentina, and Peru.

GENERAL HABITS.

The changa is essentially a subterranean insect, as all its developmental stages are spent in burrows. These burrows when just beneath the surface of the ground may be traced with ease as raised lines of broken earth winding about promiscuously. The insect seldom leaves its burrows, and then generally at night. During the day an adult is occasionally seen scurrying over the ground, but it soon enters the soil.

As may be expected from the mechanical difficulties to be overcome in burrowing through a heavy soil, the changa is never found in heavy clay lands, but in light, loamy soils. As a result the insect is much more abundant in the alluvial lands of the coast and in the inland river valleys than in the mountainous parts of the island, the soils of which are for the most part heavy clay. It is particularly abundant in light, compressible soils which allow tunnelling without the removal of loosened material. The insect avoids tunnelling on very sloping land, doing most of its work on level areas, although in very heavily infested territory even hilled-up plants are damaged. The galleries dug by the changa are more or less permanent in the heavier, loamy soils, and are used by all the changas in the immediate vicinity. The insect responds to moisture changes, as in the dry season its tunnels are carried to a depth of some 12 inches, while during the rainy season they are to be found usually within 4 inches of the surface, the depth at which the egg chamber is placed varying similarly with the season. A prolonged drought often causes an overland migration of adults and nymphs under cover of night to more favorable breeding and feeding grounds.

[1] According to Mr. Holger Johansen, for some years a resident of that island.
[2] Correspondence from Mr. Wm. Nowell, Nov. 10, 1916.

The forefeet of the changa are powerful and remarkably adapted for digging, the joints of the foretibiæ and tarsi being so articulated as to form a sharp, curved, shearing apparatus. The hard, rounded prothoracic shield is well suited for shaping the sides of the tunnel by rotary movements as digging progresses and for firming the soil in the newly made galleries.

Although clumsy, owing to the weight of its specialized forelegs, the changa is a rapid runner, even on the surface of the ground, where it often accelerates its gait by short hops. In its underground galleries it is a very rapid traveler, moving forward or backward with equal ease. Changas of the first three stages are very active, hopping many times their own length and running with great agility. The saltatory power is lost in the later instars, as the forelegs become heavier, and in leaping, the insect often somersaults in midair. The adult is also a heavy, clumsy flier and after performing long swoops lands heavily. Migrating individuals have been recorded (54, p. 256) as soaring over tree tops, and such migration to the distance of a few miles is considered probable. Flight during daylight hours has not been observed in Porto Rico, but is recorded from Georgia (54, p. 262). The adults not uncommonly fly into lighted houses during the early evening, from dusk on, especially on damp, cloudy nights.

FEEDING HABITS AND FOOD PLANTS.

The changa feeds primarily on vegetables, animal food seeming to form only a small part of its diet. Almost any young plant growth is attacked. The insect remains underground and feeds from below, commonly selecting the crown of the plant as the point of attack. When the growth is very tender the insect consumes almost the entire sprout, pulling it into the soil while feeding until only the top leaves are left above ground. Sometimes the seedling is partially gnawed through at its base. Tender roots also are often eaten.

Of the staple crops, tobacco is the most seriously damaged. Owing to the use of the Paris green and flour mixture, the changa is not now so important a pest of this crop as it once was. Practically all the grasses serve as food for the mole cricket, "grama" (*Paspalum* sp.) and "yerba dulce" (*Eleusine indica*) being its favorites among the common wild species. When sugar cane is planted on loose or sandy soils the changa sometimes causes great damage to this crop. Its injury to the young canes often makes necessary a considerable amount of replanting before a stand can be obtained. The injury to cane is confined to the germinating seed and to the bases of the young shoots, which are partially gnawed through. The boring into

cane, attributed by some writers to the changa, is probably the work of grubs. After the cane is about two months old and the young shoots have hardened, the changa is no longer a danger to the crop.

Most garden crops, and especially corn, tomato, cabbage, lettuce, and pepper, suffer severely from the changa. In the laboratory when sprouted corn was used for food the insect ate not only the stalk but in many cases the kernel as well. Nursery plantings of Livingstonea palm seedlings at the station were badly injured. Experimental plats of alfalfa were not damaged, although changas were present in the soil. Barrett (2, p. 9) has noted that plants having an acrid sap are usually free from attack.

The plants not acceptable as food are often injured by the changa's habit of trimming roots that lie along its path. Much damage of this kind may result from the active tunneling done by the insect.

The known food plants of the changa are tobacco, tomato, eggplant, potato, pepper, sugar cane, grama grass (*Paspalum* sp.), yerba dulce (*Eleusine indica*), Bermuda grass (*Cynodon dactylon*), rice, cabbage, collard, rape, turnip, cantaloup, sweet potato, lettuce, *Coleus* spp., and *Livingstonea* sp.

DESCRIPTION OF ADULT.

GENERAL DESCRIPTION.

The adult changa (Pl. I) is generally brownish in color with more or less constant darker markings. The average length without antennæ or anal cerci is about 30 millimeters (1¼ inches). Considerable variation in size is found, males varying from 19 to 34 millimeters and females from 24 to 36 millimeters.

HEAD AND APPENDAGES.

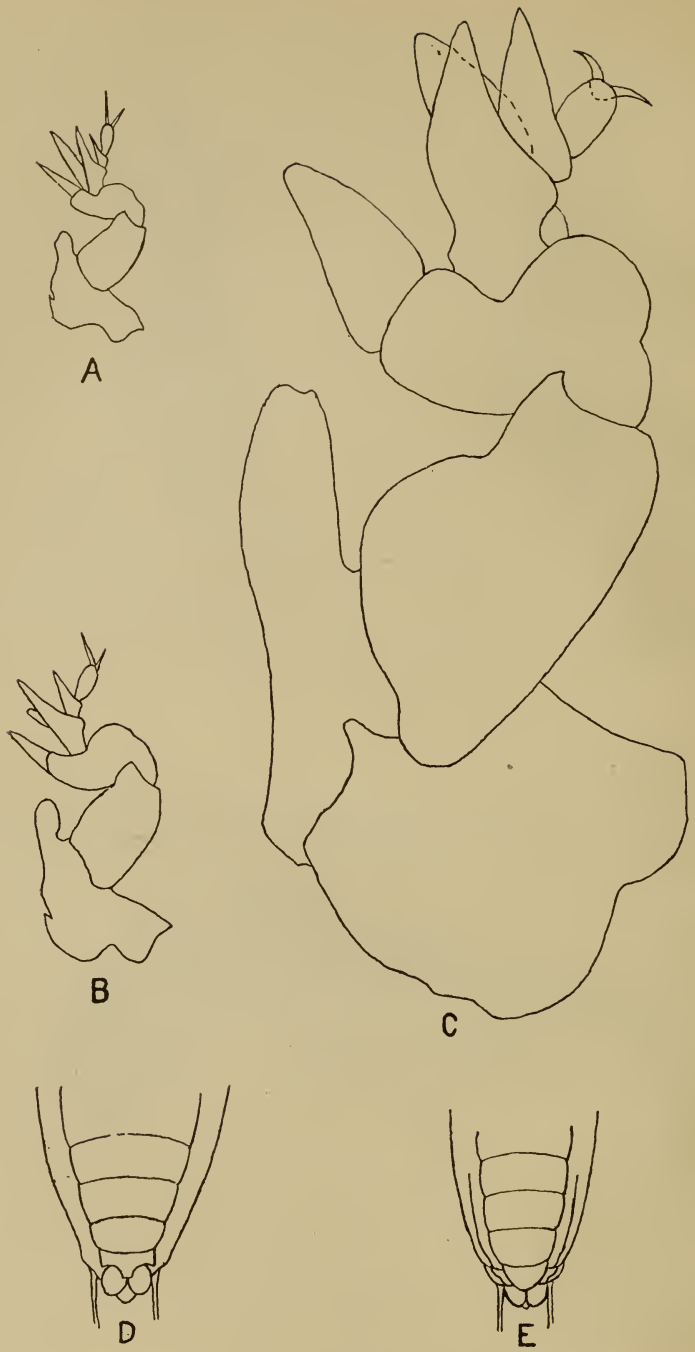
The large head is protected posteriorly by the pronotal shield. The black compound eyes are fairly conspicuous; just above and between them is a pair of pearly white, obovate, slightly convex ocelli. The antennæ arise at the lower margin of the eyes and between them; they are filamentous and about one-third the body length. The apparently unbroken antennæ of a male were composed of 87 segments, the largest number noted for the species. The clypeus is light brown and leathery and covers completely the black, heavily chitinized tips of the mandibles. The area just above the base of the clypeus is a mottled dirty white.

THORAX AND APPENDAGES.

The prothoracic shield is the most conspicuous part of the insect and is the only part of the thorax that can be seen from above. It is a tough, leathery, subovate, convex capsule, with darker markings on

FIG. 1.—FEMALE CHANGA ON LEFT, MALE ON RIGHT.
Enlarged about two times.

FIG. 2.—SEVENTH INSTAR MOLTING.
Enlarged about three times.



ANATOMICAL STRUCTURE OF CHANGA.

A, Left foreleg, first instar; B, same, second instar; C, same, eighth instar; all enlarged about eleven times. D, Abdominal segments of male; E, same of female; both enlarged about three times.

the posterior half. Its sides extend a little below the front coxæ, and its anterior margin is concave.

The tegmina or fore wings are leathery and heavily veined and extend well beyond the middle of the abdomen. The venation of the tegmina differs with the sex, but there is no variation in the tegmina of an individual. In the male the vein which forms part of the musical apparatus, and which is located on the basal third of the tegmen, makes a distinct angle of about 100 degrees with the principal longitudinal veins. In the female the prominent veins are generally longitudinal, and there is no conspicuous cross vein. The second pair of wings is more ample and delicate than the tegmina, and more finely veined. The wings fold in plaits and their apical end is rolled, the tips extending beyond the tip of the abdomen but usually not reaching the ends of the anal cerci. The pleuræ and dorsum of the last thoracic segment are provided beneath the wings with long, fine, ruddy hairs.

The greatest specialization for subterranean life is seen in the fore legs. (See Pl. II, figs. A, B, C.) Their structure is strong and powerful. The coxæ and femora are thick and muscular and the finger-like dactyls are strongly chitinized. The trochanter is a chitinous blade which serves as a support and runner for the entire leg. The tarsal dactyls are just above and outside of the tibial dactyls, and the paired blades of these structures passing just out of plane from very sharp and powerful scissors.[1]

The tympanum of the auditory apparatus is located on the upper surface of the basal part of the tibia. Instead of being concealed in a protecting cleft or fold of the chitin, as is the case in a closely allied genus, Gryllotalpa, it is only partially protected by a chitinous fold and may be easily seen as an oval white membrane stretched over the auditory chamber.

The mesothoracic legs show no particular specialization. The hind legs have the femora well muscled for leaping, and the tibiæ are spined to assist, no doubt, in landing after leaping or flight. The terminal tarsal joint of the hind leg is high and vertically flattened.

ABDOMEN AND APPENDAGES.

The abdomen is provided on the dorsal and ventral surfaces with ruddy pubescence, and the first six abdominal terga have long ruddy hairs (similar to those found on the metathorax) diminishing in length on each succeeding segment. On the lateral abdominal plates there are eight spiracles, seven of which are easily seen, while the first is concealed under the tegmina. The anal cerci arise dorsally from the tenth abdominal segment and are about one-fourth the body

[1] A fuller description of the fore leg is given by Scudder (41, p. 12).

length; they are unsegmented and provided with fine, long hairs. Their function is uncertain, but is probably sensory. The genito-anal orifice is terminal and is controlled by a three-lobed valve, one lobe of which is dorsal and the other two sublateral. In the male the posterior margin of the eighth abdominal sternum is produced into a central tooth which is docked at the tip. (See Pl. II, fig. D.) In the adult female there are only seven visible ventral segments in the abdomen (see Pl. II, fig. E), for the eighth, which is of lighter color than the rest and is not medianly prolonged into a tooth, is hidden by the seventh plate. This sexual difference can be clearly distinguished as early as the sixth instar, when, in the male the sternal tooth appears as a small median knob on the posterior margin of the sternum.

DEFENSIVE AND STRIDULATING ORGANS.

When disturbed the changa almost invariably ejects a fetid fluid from the anal orifice. Sometimes this fluid is expelled as a drop, which remains in place, but usually it is ejected to a considerable distance. The fluid itself is colorless or nearly so, but is usually discolored by the presence of soil particles. It is viscid, gives an alkaline reaction, and has a penetrating and unpleasant odor. According to Baumgartner (5) it is probably a product of Du Four's organ. All instars secrete this liquid and its use, no doubt, provides a very effective defense against enemies approaching from the rear.

The stridulating apparatus of the changa is simple. The under surface of the prominent transverse vein of the male tegmen bears a series of transverse chitinized ridges which gives the vein a filelike appearance. The characteristic chirp of the sex is made by "ruffling" the tegmina, so that the inner margin of one tegmen is drawn back and forth rapidly against the filelike vein of the other. The note produced is a short shrill chirp seldom lasting more than two or three seconds. Baumgartner (5) notes the presence of "feebly developed" stridulating organs on the female tegmina and concludes from his observations that the female also chirps. The writer has never heard the female make any note whatever.

LIFE HISTORY.

REMARKS ON BREEDING WORK.

The breeding work with the changa, summarized in this paper, was done in the insectary at Mayaguez, and all statements as to seasonal activity, duration of instars, and the like, are made for that locality only. It is likely that there is not much variation in the insect's life history at different points on the coastal plain, with the possible exception of the drier southern coast. The rainfall probably

has more direct influence than air temperature does in bringing about variations in the life history of a subterranean insect like the changa.

The cage used in procuring data on egg laying was a rectangular wooden sash, 24 inches long, 8 inches wide, and 1 inch high. Lateral grooves inside the sash, in which panes of glass could be run, permitted the depth of soil placed between the panes to be regulated. With a half inch of earth, the depth found to be most satisfactory, the runways of the adults were always in sight and could be observed without removing the glass. The cages were placed horizontally and covered with a dark cloth to simulate natural conditions. Sliced potato was at first used as food, but later sprouted corn was substituted.

As eggs were laid they were protected from the parent changas by a zinc ring the height of the space between the panes. It is possible that the egg stage was affected by keeping the eggs in a location so much more liable to temperature changes than the natural egg chamber located some inches below the surface of the ground. However, incubation of eggs in the cages seemed to be influenced as much by the moisture content of the surrounding soil as by the air temperature. It was impossible to collect exact data on the relation of length of incubation to soil-moisture content.

The young changas upon hatching were isolated in shell vials 5 inches long and 1 inch in diameter, which contained sand and sprouted corn. The changas were measured and transferred to vials of fresh food once a week until arriving at the fourth instar. After the fourth instar they were transferred to 250-cubic-centimeter Erlenmeyer flasks containing earth and sprouted corn. All changas from the fourth instar on were measured and transferred to fresh flasks every second day. Moisture conditions in vials and flasks were kept as near the optimum as possible.

Individuals reared from the egg were noticeably smaller when the final instar was reached than those taken in the field in the fourth instar or later and brought to the adult stage. The former individuals averaged about 3 millimeters less in body length and about 1.5 millimeters shorter in medial length of the pronotum.

It is not probable that the unnatural conditions under which the rearing work was done affected the length of the developmental stages very seriously, for nearly mature changas taken in the field and brought through to the adult stage in the laboratory averaged about the same length of time for the last two instars as did individuals reared from the egg. Furthermore, the total length of the egg stage and developmental and preoviposition periods, as determined in the laboratory, equals about one year, which corresponds with field observations. In nature the postembryonic developmental stages are perhaps somewhat shorter than in the insectary.

SUMMARY OF LIFE HISTORY.

As a rule, there are eight molts after the egg stage, although occasional males molt only seven times. The entire period from the egg stage to the adult averaged 295.3 days for 19 individuals, 11 of which were males averaging 281 days with a variation of 233 to 321 days, and 7 females averaging 321 days, with a variation of 291 to 397 days. About a year is required for the full development of a generation.

The duration of the different instars is shown in the accompanying table:

Duration of instars of changas reared from the egg.

Instar.	Number of individuals averaged.	Duration in days.		
		Maximum.	Minimum.	Average.
1	52	67.5	23.0	40.2
2	38	59.5	13.0	29.4
3	31	65.0	12.5	26.8
4	32	58.5	16.5	27.5
5	27	49.0	18.0	30.0
6	20	94.5	25.0	47.5
7	17	62.0	27.0	45.7
8	15	75.5	38.0	54.1

The preoviposition period of adult females is long. Three individuals averaged 79 days between the time of becoming adult and the first egg laying, 62 days being the shortest time and 93 the longest for this period.

That adults may live several months under favorable circumstances was shown by tests made with adults placed in battery jars filled with earth and provided with ample vegetable food. The longest adult life recorded was of a male which was eaten by a female 160 days after the final molt. An adult female taken in the field died a natural death after being kept alive for 127 days.

The numerical proportion of males to females bred in captivity was about equal, and the same is true of captures made in the field. Individuals have been brought to the adult stage every month of the year in the insectary, but there seems to be a fairly well-defined preponderance of final molts during the fall months. It is possible, therefore, that the flight to lights so marked during October, November, and December is in part at least a nuptial flight. All stages may be found in the field at any time of the year.

EGG STAGE.

The newly egg is gray in color and oblong-oval in shape, with a shiny, unsculptured surface (Pl. III, fig. 1), measuring about 3 millimeters long and 1.7 millimeters wide. The egg increases con-

FIG. 1.—NEWLY LAID CHANGA EGGS IN EGG CHAMBER.
Enlarged five times.

FIG. 2.—TEN-DAY-OLD EGG, EGGSHELL, AND FIRST STAGE OF CHANGA.
Enlarged five times.

siderably in size as the embryo develops, and five eggs within two or three days of hatching averaged 3.9 millimeters in length and 2.8 millimeters in width.

The eggs are deposited in an oval chamber measuring about 1½ inches long, 1 inch high, and 1 inch wide. The depth at which this chamber is located varies with the time of year at which it is made, as in the dry season it is some 8 inches underground, while in the wet season it may be within 3 inches of the surface. The chamber is a blind pocket leading off from one of the galleries; its entrance is concealed by a packing of loose earth after the eggs are laid to protect them from nymphs or adults. The eggs are dropped by the female in a loose heap. Egg clusters laid in captivity had an average of about 20 eggs, the largest heap containing 40, but in clusters found in the field the average rose to about 25. The egg is ejected very quickly, and the insect usually rests for a second or two before ovipositing again.

The greatest number of eggs deposited by any one female in captivity was 110 in four lots, and an examination of females taken in the field (some of which had no doubt already begun laying) failed to show more than this number of eggs in the ovaries. The changa laying 110 eggs, adult when captured, began to oviposit after 21 days, continuing for 57 days at intervals which averaged 18 days and dying the day the last cluster was laid. This was the longest oviposition period observed. Females in captivity deposited eggs every month of the year except December, the greatest activity being shown during April, May, and June.

The duration of the egg stage averaged about 19 days for 20 lots, with variations from 15 to 38 days. No relation was observed between the period of year at which eggs were deposited and the duration of the egg stage.

Besides increasing in size as development progresses the egg becomes ovate in shape, owing to the greater enlargement of one end, and changes from its gray color when first laid to a dirty, yellowish white. For some time before hatching occurs the chitinized mouth parts of the young changa within can be seen as a dark spot near one end of the egg. At hatching the chorion of the egg splits longitudinally, and the young changa emerges, backing its abdomen out first and lastly withdrawing its head from the shell. Under natural conditions practically all of the eggs hatch, only an occasional egg of a cluster appearing to be infertile, and the few that do fail to hatch are usually eaten by the first arrivals of the same brood. Eggs can not survive being deposited in a very dry location. Some eggs kept in the laboratory on dry sand for three weeks became shrunken and dry, and although they regained their original plumpness when placed on moist sand they failed to hatch. The check group from the same cluster hatched normally.

POSTEMBRYONIC STAGES.

With the exception of the dark-brown maxillæ and mandibles the newly hatched changa is snow white at emergence. A light oval area covers the greater part of each compound eye. Within an hour after hatching takes place the margins of the head, prothorax, legs, and antennal segments become dirty white, later changing gradually to a light gray. The abdomen is greenish white, acquiring a gray color more slowly and finally remaining lighter than the other parts of the body.

After leaving the egg the young changa is very active and begins feeding almost at once, not requiring care from an adult as a European mole cricket (*Gryllotalpa* sp.) is said to do.[1] Its diet consists of plant food, the weaker members from the same egg cluster, and perhaps an occasional egg. As the food requirements are small during this instar and the three stages following it, no noticeable damage is done to plants. One changa used in a starvation experiment survived the first instar without any food and died 22 days after hatching while in the act of the molting for the first time. At first the little changas are gregarious, but they soon wander off to the main gallery or make tunnels of their own.

In the first stage the changa is about 6 millimeters long, not including antennæ or cerci (Pl. III, fig. 2). The pronotal shield measures about 1.9 millimeters in median length and about 1.6 millimeters in width. The antennæ consist of 34 segments; no ocelli are present. The wing pads are not apparent on the first two abdominal segments. The tympanum is present on the foreleg. The foreleg itself is more slender than in later instars and has not the high specialization for fossorial life than it later acquires.

The succeeding stages of the changa resemble the first stage more or less, practically the only differences being in size and in development of the forelegs and of the wings. The wing pads are first noticeable in the second instar as small lateral projections of the dorsal plates of the first two abdominal segments. These budlike wing pads increase in size with each succeeding molt and become plainly noticeable in the fifth instar. The number of antennal joints increases with each instar from the 34 found in the newly hatched changa to well over 80 in the eighth-stage individual. The ocelli first become noticeable in the second stage, when they can be seen as elongate, hyaline, raised areas. The sternal tooth on the abdomen of the male can be discerned in the sixth stage, appearing as a small knoblike projection on the middle of the posterior margin of the eighth plate.

[1] Sharp, D. Insects, I. Cambridge Natural History, vol. 5, p. 336. London, 1895.

The average measurements of the different instars of changas bred from the egg and from individuals taken in the field are shown in the following tables:

Average measurements of changas.

BRED FROM EGG TO ADULT STAGE.

Instar.	Pronotum.		Wing pads.		Body length.
	Length.	Width.	1	2	
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*
1	1.9_{35}	1.6_{3}	.....	.....	6.1_{16}
2	2.9_{46}	2.4_{4}	.....	.....	8.9_{2}
3	4.1_{38}	3.4_{21}	.....	.....	13.1_{3}
4	4.9_{33}	3.9_{22}	.....	.....	16.3_{6}
5	5.8_{31}	4.8_{20}	.....	.....	18.9_{7}
6	6.5_{27}	5.3_{20}	.....	2.1_{4}	21.4_{5}
7	7.1_{15}	5.9_{15}	2.5_{9}	3.1_{15}	23.0_{9}
8	7.6_{14}	6.5_{14}	4.9_{12}	6.3_{13}	26.6_{11}
Adult	7.8_{14}	6.9_{15}	12.2_{6}	18.3_{6}	27.5_{8}
Female	7.6_{5}	6.8_{6}	12.3_{3}	19.2_{3}	27.5_{4}
Male	7.9_{9}	6.9_{9}	12.1_{3}	17.5_{3}	27.5_{4}
CAPTURED IN FOURTH INSTAR OR LATER AND BRED TO ADULT STAGE.					
7	7.6_{10}	5.9_{9}	2.7_{2}	3.2_{6}	25.2_{3}
8	8.3_{26}	6.6_{26}	5.2_{20}	6.7_{20}	26.6_{18}
Adult	9.1_{70}	7.3_{70}	15.5_{23}	20.7_{29}	30.4_{26}
Female	8.9_{38}	7.3_{38}	15.6_{16}	21.4_{18}	31.1_{16}
Male	9.3_{31}	7.4_{31}	15.1_{7}	19.5_{11}	30.4_{9}

NOTE.—Inferior figures indicate the number of individuals averaged.

MOLTING.

Molting, as a rule, takes place underground in a cell constructed for the occasion and similar in shape to the egg chamber, though the process can be successfully accomplished above ground also. The skin splits dorsally from the front margin of the thoracic shield to about the third abnormal segment (Pl. I, fig. 2). First the thorax and abdomen are freed, and finally the head, legs, and antennæ. The entire process takes less than half an hour, and within two or three hours the body has regained its normal colorations. For a week or more before molting the changa is noticeably yellowish in color, and the wearing off of the pubescence covering the body gives it a greasy appearance. After molting the changa is dark brown to black, with a fresh, velvety appearance produced by the new pubescent coat.

Two males reached the adult stage with the normal tegmina of this species, but with metathoracic wings aborted and completely hidden by the fore wings. Not uncommonly changas in capacity are found unable to free the legs and mouth parts in molting.

NATURAL CONTROL.

The natural control of the changa, that is, its reduction to unimportant numbers by natural enemies, either parasitic or predacious, is obviously a failure in Porto Rico. The insect has numerous enemies, but their combined efforts are not sufficient to hold the mole cricket in check.

PARASITES.

In Cuba an unidentified Tiphia (10) has been reported as a probable parasite of the changa, but it has been found only once. It was recovered from a changa burrow with portions of a mole cricket's exoskeleton worked into the cocoon. In Georgia, a tachinid fly is said to parasitize impoverished females, but this is more a scavenger than a parasite (54, p. 261).[1]

No parasitic enemies of the changa have been reported from Porto Rico. Two eighth-stage females kept in confinement during the breeding work were found after death to contain vast numbers of nematodes. These individuals had a peculiar "slick," greasy appearance for some weeks before they died. Prof. Henry B. Ward,[2] of Urbana, Ill., to whom one of the changas was referred, stated that there was little doubt that the nematode in question is a true parasite, but that identification of the material was impossible.

PREDACIOUS ENEMIES.

Insects, myriapods, reptiles, etc.—Several vertebrates and invertebrates feed upon changas in all stages; some, because of their nocturnal or subterranean habits, probably are important enemies of the mole cricket.

The common centipede (*Scolopendra alternans*)[3] probably occasionally feeds on the mole cricket. Its nocturnal habits, its liking for locations beneath boards and stones where changa burrows most frequently come to the surface of the ground, and its very rapid movements in attack, together with its generally carnivorous habits, make it very likely that this myriapod feeds on changas under natural conditions. In the insectary, on more than one occasion, a centipede entered the flat rectangular cages in which mated pairs of changas were confined and devoured the insects. Centipedes in captivity killed changas as fast as they were offered, far in excess of their food needs. The myriapod strikes and coils itself about its victim with great rapidity, generally attacking on the side behind

[1] Also correspondence from Mr. W. V. Reed, Nov. 17, 1916.

[2] Letter of Mar. 1, 1917.

[3] Determination made through the kindness of Mr. Roy W. Miner, American Museum of Natural History, New York.

and beneath the thoracic shield. Paralysis of the limbs follows almost at once, and in from 3 to 10 minutes the changa is lifeless.

A large gray hairy spider, called 'araña peluda," is not uncommonly found in the soil and may account for an occasional changa. Individuals in captivity devoured the mole crickets greedily.

Tower (46) records the adult of *Tetracha sobrina infuscata* as an enemy of the changa in the tobacco district in the interior of the island. This tiger beetle seems to be generally distributed over the island but is not very common.

Calosoma alternans is another probable enemy of the mole cricket. An adult female of this species was found in a changa burrow at a depth of about 6 inches. In the laboratory the beetle killed four changas in about two weeks and fed upon them from time to time. This insect, which is also predacious on small Lepidopterous larvæ, may be a more effective enemy of the mole cricket under natural conditions, but it is not a very common species.

Larvæ of *Pyrophorus luminosus*, in the absence of other food at least, will attack changas of any stage. This generally beneficial insect which is so common in the lowlands may be an effective enemy of the mole cricket.

In Cuba a red ant known locally as "hormiga brava" attacks the changa in its burrows and may be an important factor in keeping down its numbers. This is not the same species as the Porto Rican ant which has the same common name.[1]

The value of the various lizards (*Anolis* spp.), so numerous over the island, as predators of the mole cricket is very small because of their diurnal habits. A changa emerging above ground during the daytime, however, is almost certain to furnish a meal for some lizard.

The larger "siguana" (*Ameiva exul*) has the reputation of being a valuable enemy of the changa, and since it is a burrowing animal no doubt it does feed to a greater extent on the mole cricket than do the more common and smaller lizards. The stomach of an Ameiva collected at Yabucoa and examined by Mr. Wetmore contained fragments of a changa, and this species has been observed to dig out and devour mole crickets at Rio Piedras.[2] However, examination of the stomachs of four of these lizards taken at Mayaguez failed to reveal any traces of changas. In St. Lucia it is reported (6) that "previous to the introduction of the mongoose the mole cricket was kept under control by its natural enemy the ground lizard." This possibly refers to *Ameiva* sp.

[1] Correspondence from Mr. Patricio Cardín, entomologist of the Agricultural Experiment Station at Santiago de las Vegas, Cuba.

[2] Letter from Mr. E. G. Smyth, of the Porto Rico Insular Experiment Station, Feb. 7, 1917.

Fredholm (18) states that the common Trinidad garden toad gorges itself upon the mole cricket. This is a South American species and maintains itself only where the mongoose is kept down. There are at least two species of Texas toads, nocturnal in habit and generally insectivorous, which might upon introduction reduce the numbers of the Porto Rican mole cricket (48) were it not for the mongoose which now overruns the island.

Birds.—The most efficient enemies of the changa are to be found among the native birds. The comparative value of the various species has been determined by Wetmore (53), from whose publication the following notes are taken:

The blackbird (*Holoquiscalus brachypterus*), popularly considered one of the greatest enemies of "la changa," in reality destroys but few. * * * Other species, however, make up for the blackbird's shortcomings, and among them the despised martinete (*Butorides virescens cubanus*), ridiculed for its ungainliness, ranks foremost. Standing watchfully, with head drawn in, among the short growth of the young cane fields, or walking with lengthened stride along the border of lowland pools, it spies and avidly swallows both adults and young of the mole cricket. The species at present known to aid in suppressing this pest number 21, and following is a list of them arranged somewhat in order of importance (figures following the name indicate the percentage formed by the mole cricket in the total bulk of the food):

Bird enemies of mole cricket.

[From Wetmore.]

	Per cent.
Martinete (*Butorides virescens cubanus*)	54.33
Falcón (*Falco sparverius loquacula*)	28.69
Playero (*Oxyechus vociferus rubidus*)	14.42
Putilla (*Actitis macularia*)	10.78
Garza (*Florida cærulea cærulescens*)	7.23
Judío (*Crotophaga ani*)	5.69
Ruiseñor (*Mimus polyglottos orpheus*)	3.62
Clérigo (*Tolmarchus taylori*)	3.04
Pitirre (*Tyrannus dominicensis dominicensis*)	2.36
Juí (*Myiarchus antillarum*)	1.27
Garzón blanco (*Herodias egretta*)	1.00
Julian chiví (*Vireo latimeri*)	.90
Zorzal (*Mimocichla ardosiacea portoricensis*)	0.86
Múcaro (*Gymnasio nudipes nudipes*)	.60
Canario de manglar (*Dendroica petechia bartholemica*)	.25
Gorrión (*Coturniculus savannarum intricatus*)	.25
Mozambique (*Holoquiscalus brachypterus*)	.21
Calandra (*Icterus portoricensis*)	.21
Pajaro bobo (*Coccyzus minor nesiotes*)	.21
Zorzal negro (*Margarops fuscatus fuscatus*)	.16
Becacina (*Gallinago delicata*), one bird only examined	

The Cuban green heron [martinete] is one of the commonest birds in Porto Rico and is distributed all through the coastal plain. * * * Clumps of bamboos along streams were favorite perches. To these growths numbers retired to escape the burning heat of the midday sun, and in many localities they were used as nesting sites. Most of these birds, however, still nest in the mangroves and swampy growths bordering lagoons and lowland streams. * * * Three stomachs [of this species] taken in January and two in August contain little else [besides bodies of the changa], while the smallest proportion—13 per cent—occurs in the month of June.

[This bird] from the standpoint of the agriculturist is one of the most important species on the island. It should be protected, especially at nesting time, and encouraged by planting bamboos as permanent shelters along streams and drainage ditches. This species should hold its own and even increase largely, because of its adaptability to new conditions. The south coast especially, with the present area under irrigation, * * * is very favorable to the green heron, and this bird is one of the few economic species especially adapted to that region.

The Porto Rican sparrow hawk or falcón (*Falco sparverius loquacula*) is another important enemy of the changa, the insect constituting about 29 per cent of this bird's total food. It is most common in the foothills.

To encourage the birds about cane fields occasional high perches from which they can watch for prey should be provided along the fences. Their numbers should increase in the lowland region, as their natural food [consisting mainly of lizards and mice, in addition to insects] is abundant and easily obtained.

Wetmore adds that although valuable insect-feeding lizards are eaten by the falcón, the reptiles are so numerous that no impression is made upon them, and this bird must be considered as a valuable species because it feeds so largely upon the changa.

In St. Vincent the West Indian hawk (*Buteo antillarum*) is recorded by Clark (12) as feeding to some extent upon the mole cricket, since the lizards, its more usual food, have been so greatly reduced in numbers by the mongoose.

Domestic animals.—Barnyard fowls, especially chickens, have long been recognized as voracious feeders on the changa. Comparatively few of the mole crickets are accessible to them, and their usefulness is thereby restricted to areas which are being plowed or spaded. One writer (43) records that chickens in St. Vincent are frequently killed by devouring live mole crickets which burrow out of the alimentary canal. At this station two native Porto Rican chickens about 2 months old were fed upon corn and live changas of all stages for about a week with no ill effects.

Hogs, which are valuable in cleaning land of white grubs, are not averse to devouring changas. In very badly infested areas good results may be secured by turning in hogs to feed before setting out the crop.

FUNGUS AND BACTERIAL DISEASES.

A small percentage of changas in the breeding cages died from what seemed to be a fungus disease. An eighth-stage female which was submitted to Dr. Alden T. Speare, mycoentomologist of the Bureau of Entomology, of the United States Department of Agriculture, was found to be infected by *Metarrhizium anisopliæ*. Even under laboratory breeding conditions, which were by no means

ideal as regards freedom from fungi, only about 1 per cent of the changas handled could be even doubtfully classed as killed by this fungus.

Two experiments on a small scale with *Micrococcus nigrofaciens*, a bacterium pathogenic to white grubs and to some Blattids,[1] resulted negatively as far as the changa was concerned.

CANNIBALISM.

Cannibalism among changas is common under laboratory conditions. When changas were kept in pairs, although provided with plenty of vegetable food, one or the other sex was almost certain to be killed within a month. Under natural conditions cannibalism is probably greatest during the first few days following the hatching of an egg cluster. At that time the newly hatched changas remain together in their chamber, and a few of the weaklings, as well as some of the eggs, serve as food for the stronger or earlier hatched members of the brood. Both adult males and females devour the eggs when opportunity offers, but in nature they rarely happen upon the egg chamber. Imperfectly molted individuals in the breeding jars were often killed by other changas.

ARTIFICIAL CONTROL.

Control measures for the changa may be divided into preventive and remedial. The value of either class depends entirely upon local conditions.

PREVENTIVE MEASURES.

Mechanical devices.—One of the earliest methods used in combating the changa was the wrapping of mamey leaves (*Mammea americana*) about the roots of seedlings in transplanting. This method was in use chiefly among tobacco growers and gardeners. Other leaves said to be effective in protecting the roots from the mole cricket's ravages are those of pomarrosa (*Eugenia jambos*) and ausubo (two species are included under this common name, *Mimusops nitida* and *Sideroxylon fœtidissimum*). This method of leaf-wrapping hinders the rooting of the plants and sometimes causes water to stand about the roots. Mamey leaves rose in price as they became more scarce, and their use practically ceased. Their place was taken by cylinders made of tin, heavy paper, or wire. Plants are set within these cylinders, and the top of the cylinder allowed to project on inch or two above the surface of the ground. These cylinders are

[1] Northrup, Zae. Michigan Sta. Tech. Bul. 18 (1914).

expensive, and in addition, those of tin and paper cause unnatural rooting conditions. Mamey leaves and cylinders will always be used to some extent in small gardens for valuable plants, but their use on a large scale is past.

Repellents.—The most satisfactory repellents are flowers of sulphur and naphthalin flakes, though neither of these is completely successful where changa infestation is very severe. Dry sulphur drilled in with corn at the time of planting offers fair protection. Powdered naphthalin laid in parallel trenches ½ inch deep and 1 inch from the seed row is an effective repellent as long as it retains its odor, usually about three to five days. Naphthalin so used did not hinder germination of corn or lettuce. The high cost and extreme volatility of carbon bisulphid make the use of this chemical out of the question.

Kerosene emulsion is an effective repellent, but only at such strengths and in such quantities as to injure vegetation. Other materials found to be either useless as repellents or injurious to plant life are lemon oil, mustard oil, citronella, and creosote. Barrett (2) lists as unsuccessful repellents for the changa creolin, coal tar, lime, and tobacco (both as a dust and a stem mulch). Other writers have recommended heavy applications of "greasy manures" (22) and of kainit.

Methods of planting.—Planting of sugar cane in a perpendicular or slanting position has solved the changa problem for this staple crop. When one or two eyes are left above ground, shoots are produced out of reach of the changa. After the shoots have become sufficiently tough to resist further attack from the mole cricket, the sprouts may be partially covered over with earth. Leaving portions of the leaf-sheath over the eyes will also protect the tender sprouts from the changa.

Hilling-up is often successfully employed to protect plants against the changa, advantage being taken of the insect's aversion to making its burrows up slopes. However, the writer has seen heavily infested fields where hilling-up had apparently had no effect.

Clean cultivation of land in itself is not an effective means of protecting the crop which is to follow. It should be considered only as a step in preparing for the use of poisoned baits. Although the removal of all vegetation may cause the insect to migrate to other feeding grounds, migration takes place only after the absence of food for several days has made the pinch of hunger felt, and in a country where grasses grow so luxuriantly as in Porto Rico, keeping land clean for more than a week would be more costly than the result would warrant. In the laboratory the starvation period of both first stage and adult changas averaged about 22 days. In the field the presence of other insect food would lengthen this period.

REMEDIAL MEASURES.

Plowing.—Plowing is of great value in changa control, for large numbers of the insects are exposed to chickens, lizards, and other enemies. In addition, egg chambers are broken up and some eggs exposed to the sun, a few hours' exposure to the direct rays of the sun apparently preventing eggs from hatching.

Trapping.—During October, November, and December changas take flight in large numbers, most commonly on cloudy, overcast evenings. The insects appear in largest numbers just after dusk, few flying after 9 or 10 o'clock. The surprising fact was noted in captures at lights at Mayaguez and at Rio Piedras (on a single evening at the latter place) during October, 1916, that the females outnumbered the males more than two to one. This disproportion fell somewhat with later captures, but females were still in the majority in January, 64 per cent of the total catch belonging to this sex. A large proportion of the females captured during the fall were sexually immature.

A season's experience with trap lights has indicated that their use is not generally practical against the changa. It is only on the rare occasions when the mole crickets fly in large numbers that it will pay to operate a light trap, as at other times the catch will be very scattering. Observation will determine whether the insects are abroad in sufficient numbers to make the running of the light profitable.

The trap light should be very bright, and the pan of oil and water placed beneath should be as large as can be had. As the mole cricket is not attracted to the light, but only to its vicinity, it would pay in case only a small pan is available, to have the changas that fall outside the receptacle picked up. It is useless to keep the light going after 10 o'clock.

Large bonfires in the fall of the year are said to attract and destroy large numbers of the changa.

Traps made by sinking wide-mouthed bottles in the earth up to the mouth were found to be useless, even when baited with cornmeal.

Burlap bags are said to be successfully used as traps for mole crickets in the Isle of Pines. The bags are laid flat on the ground, inspected early each morning, and the crickets found under them are killed. Some writers state that mole crickets congregate beneath compost heaps and can be captured there in large numbers.

Flooding.—It may sometimes be found practical to flood areas easily reached by irrigation canals. Flooding formerly practiced [1]

[1] According to Mr. Holger Johansen.

on a small area near the river at Central Fortuna is said to have resulted in a noticeable decrease in changa injury. Nymphs or adult changas are not killed even by complete submersion for three hours, and in the field all instars usually will make their way to the surface within that space of time. In laboratory tests, changas readily made their way to the surface through 6 inches of flooded soil, and once on the surface of the water they float easily, owing to their air-retaining, pubescent coat. Exposure for even a short time in the field will give insectivorous birds, such as the martinete, ample opportunity to devour them. Although active swimmers, probably few of the insects will escape the watchful eyes of the water birds.

In four laboratory tests clusters of changa eggs, either newly laid or almost ready to hatch, failed to survive a submersion of 24 hours. The checks hatched normally.

Poison baits.—Poison baits against the changa are most successful upon small areas, such as garden plats. The cost is an important objection to their use over larger areas, although they have been found practicable by large tobacco planters. Success depends on having the land so clean of all vegetation that when the bait is applied the changas will be hungry enough to accept it greedily. As the native grasses are among the mole cricket's favorite food plants, clean culture applies to the grasses as well as to crop remnants.

The most satisfactory bait yet found is a dry mixture of 3 per cent Paris green with cheap flour. Flour of the poorest quality, even that ruined by weevils and moths, is satisfactory for this purpose, corn meal, cottonseed meal, and bran making good substitutes, though flour seems to be preferred by the changa. Barrett (2, p. 16) reported very satisfactory results from the use of a mixture of grass stems, molasses, and Paris green. The Paris green and phosphorus mixture used against crabs is said to be acceptable to changas as well.

The Paris green and flour bait may be applied in a shallow trench around the young plant at a distance of an inch or more from the main stem, it may be introduced into a changa gallery where it approaches the surface, or it may be spread broadcast over the land. The last method is applicable to especially heavily infested lands. After the area to be treated has been kept clean of vegetation for three or four days, the mixture should be applied, preferably in the late afternoon, at the rate of 300 pounds to the acre. The crop may be planted three to five days after spreading the bait. This treatment on cabbage beds at the Mayaguez station resulted in 50 per cent better stand on the treated plats than on the checks. The broadcast treatment has the added advantage of killing other injurious plant-feeding insects, such as other crickets and cutworms.

Mr. Harrison Johnson, of the Cayey-Caguas Tobacco Co., has the following to say[1] in regard to the use of the Paris green and flour mixture in tobacco plantings:

I can give no definite figures, but in my opinion the success of a seed bed where this remedy is used is insured fully 50 per cent over another handled under old methods. This application enables the grower to plan for seed plants at a specified time, which is extremely vital to him, owing to the limited period available for planting. The application of flour-Paris green in the fields has likewise proven a blessing for a great many reasons; the percentage of loss is considerably less than when the mamey leaf was used, and the free seedling starts off unhampered at once; a more even stand is obtained, and the poison will undoubtedly reduce the changa population in the immediate fields very materially. The changa is no longer the menace to the tobacco planter who will avail himself of this proven remedy.

Experiments have failed to demonstrate any increased effectiveness for baits containing salt, citrus juice, molasses, or honey. A distinct objection to the use of sweetening substances is that they make the bait very attractive to ants, which soon carry the material away. Fowls and domestic animals, of course, should be kept from access to poisoned mixtures.

GENERAL REMARKS ON CONTROL MEASURES.

The changa is by no means impossible of control, even though the problem at times is discouraging to the general gardener. The use of poison baits, either alone or in conjunction with such measures as trapping or perhaps flooding, should make crop raising possible even in the most heavily infested areas. Vigorous remedial measures employed year after year in some of the tobacco districts have resulted in rendering unimportant what was once a most threatening enemy of tobacco seed beds. Similar results can be obtained with other crops, but it should be borne in mind that control measures must be consistently continued to prevent reinfestation. Probably it will always be necessary to employ artificial means against the changa in Porto Rico, and though the insect can never be stamped out completely, it may be controlled by the exercise of vigilance and energy.

SUMMARY.

(1) The changa is a native of the West Indies and South America, but does its greatest damage in Porto Rico. It is the principal insect enemy of general agriculture in the island.

(2) The insect feeds on almost any tender vegetable growth, usually attacking the plant at the crown just beneath the surface of the soil. It also does much damage by cutting roots that lie along its paths.

[1] In correspondence.

(3) The life cycle covers about one year. About three weeks are required for the egg state; about nine months for development from hatching to the adult stage; and over two months for the preoviposition period.

(4) Although the mole cricket has many natural enemies, particularly among the native birds, it is not held in check by them.

(5) With the exception of a nematode, no parasitic enemies of the changa are known to occur in Porto Rico.

(6) During the fall months the changa flies in large numbers on damp, overcast evenings. The greater proportion of changas attracted to lighted areas are females. Flooding is of value wherever the location of fields makes water easily available.

(7) Naphthalin and sulphur are the only repellents found to be of any value, and even they are only partially effective.

(8) Sugar cane is protected from the changa by planting it in a perpendicular or a slanting position. Hilling up plants greatly reduces changa injury in gardens.

(9) The use of poison baits, together with clean cultivation of the area to be planted, is recommended. A mixture of cheap flour and Paris green is particularly acceptable to the changa.

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